(12) UK Patent Application (19) GB (11) 2 089 545 A

(21) Application No 8039240
(22) Date of filing 11 Dec 1980
(43) Application published
23 Jun 1982
(51) INT CL³
G06K 9/20
(52) Domestic classification
G4R 11D 1X 2B 2E 9B
(56) Documents cited
GB 2007899A
GB 2007415A
GB 1548667
GB 1509095
GB 1399675
GB 1397903
GB 1305248
GB 1172539
GB 1074858
(58) Field of search
G4R
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(54) Optical Image Formation

(57) An internally reflective boundary surface 26 between media of different optical refractive index is locally interrupted by contact with the surface contours of an object 21 (e.g. a fingerprint) to be viewed, the object 21 being illuminated by a light source 29 situated along an internally reflecting light ray path from the source 29 via the internally reflecting surface 26 to an image viewing or projecting station 36, 37, to produce an image in highlighted or silhouette form. The surface 26 may be one surface of a glass prism or the surface between two liquids in which the object 21 is partially immersed.

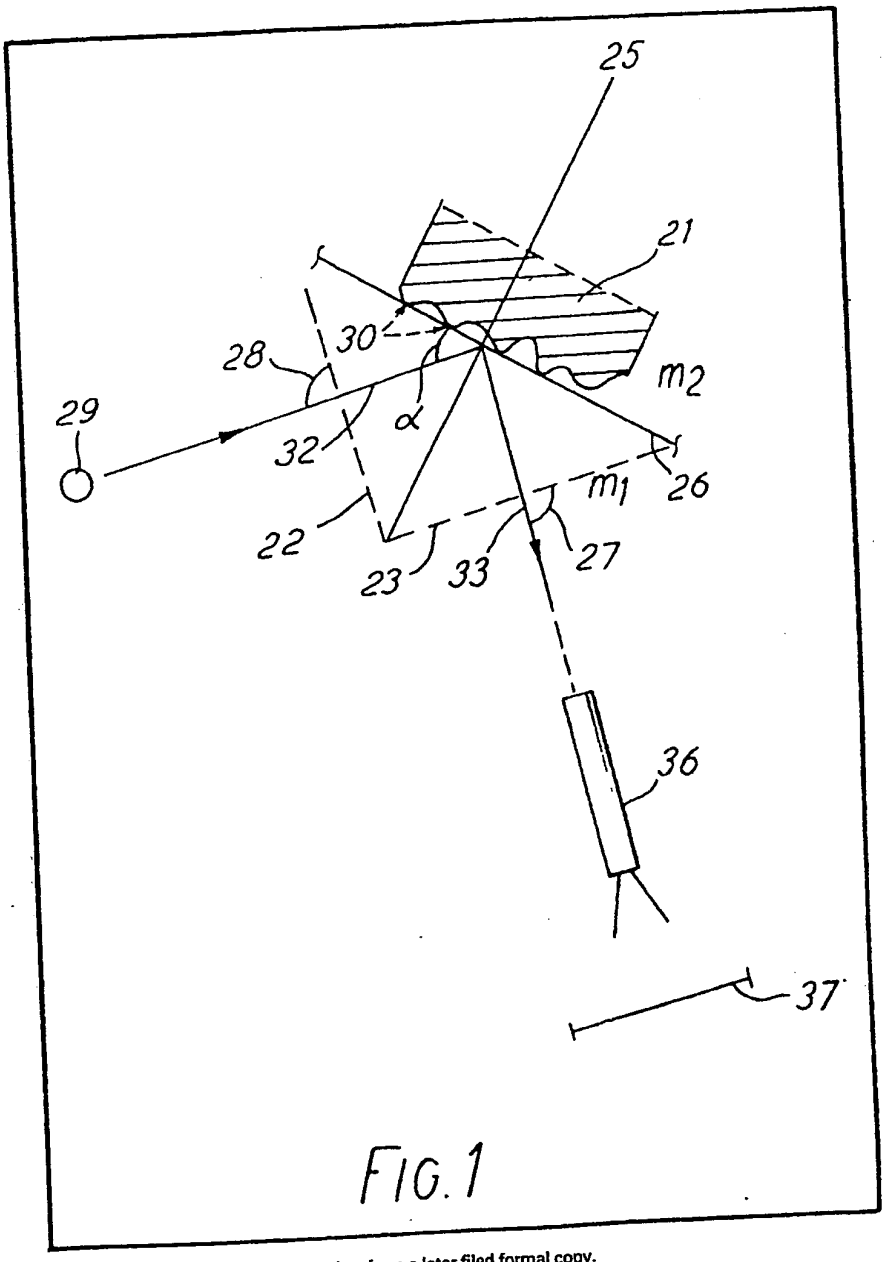

FIG. 1

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The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

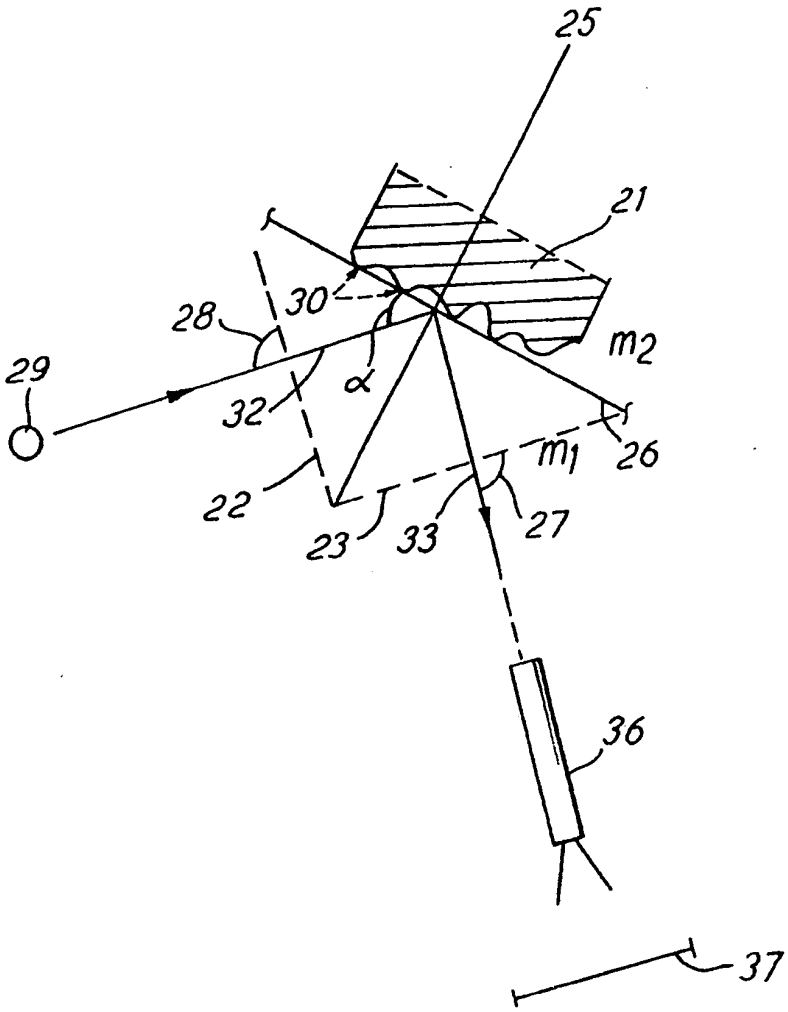

FIG. 1

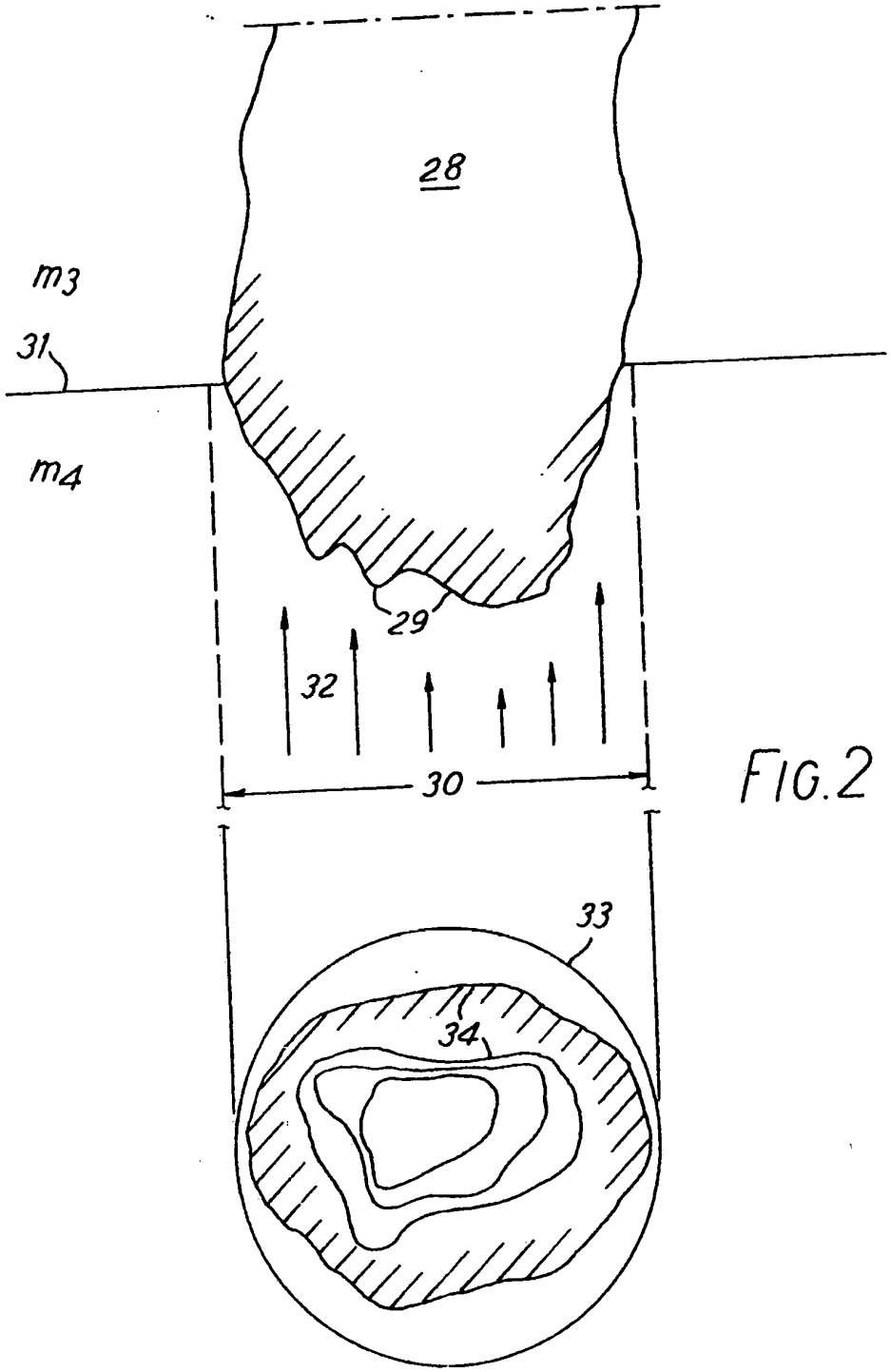

FIG.2

SPECIFICATION

Optical Image Formation

This invention relates to optical image formation and is particularly, but not exclusively, concerned with the formation of an image of a three dimensional contoured surface in highlighted or silhouette form.

An important application of the invention is in the formation of a finger print image suitable for human and/or electronic optical recognition purposes. Specifically, an image comprising well defined contrasting light and dark areas may be scanned to produce a digital electrical signal compatible with electronic data processing and storage. Thus comparison of an individual finger print with a store or reference collection may more readily be made, without the necessity for a bulky or cumbersome permanent printed record, such as an ink impression or photograph.

According to one aspect of the invention there is provided image formation apparatus comprising a light source, an internally reflective surface defined at the boundary between two media of different refractive index, means for applying an object to locally interrupt said boundary surface, together with viewing or projection means for receiving and viewing or projecting an internally reflected image from said surface to form an image exhibiting contrast between reflected and non-internally reflected light rays from such surface, in highlighted or silhouette form.

The invention also provides image formation apparatus comprising a glass prism located in an air medium, to provide an internally reflective surface in the prism between the glass and air interface, for light rays from an image along a viewing axis, the reflection being along a projection or image viewing axis; means for applying an object with distinct surface contours to contact the glass air interface in order to interrupt locally the glass air interface and thereby locally to affect the internally reflective properties thereof, whereby to form a highlighted or contrasted image of relatively dark outlines of said object surface contours, against a relatively light, silvered or reflected background, representing the light source.

According to another aspect of the invention there is provided a method of forming a highlighted or contoured image, comprising the steps of applying the three dimensional surface of an object whose image is to be highlighted to an internally reflecting refractive surface layer between two media of respective differing refractive index, to interrupt locally the internal reflection effect between the two media, whereby to produce said highlighted or contoured image in two dimensional form.

It is envisaged that additional optical effects, for example using the properties of polarised light, including polarisation by reflection, may be employed in order to enhance the highlighted forms of the image produced.

There now follows a description of a particular embodiment of the invention, by way of example only, with reference to the accompanying diagrammatic drawings, in which:

Figure 1 shows surface contour projection apparatus for an internally reflecting surface, specifically for displaying a finger print; and

Figure 2 shows an equivalent arrangement to that shown in Figure 1 but utilising liquid media.

Referring to Figure 1, a light source 29 is arranged to direct rays of light 32 towards an internally reflective surface 26, which forms the boundary layer between two media M1 and M2 of different optical refractive index, such as to produce total internal reflection of certain light rays directed between the media. Thus the angle of incidence 'α' of the light rays 32 with respect to the surface 26 is such as to achieve total internal reflection along a light path 33 towards a viewing or projecting means 36, for example comprising a suitable collator and lens array, which in turn forms at the remote end thereof from the surface 26 a viewable image at an eyepiece or a projected image on screen 37. The size and range of values of 'α' may vary according to the media and in some cases a value of 'α' approaching 90° may be achieved.

It will be appreciated that such internal reflection may occur all along the surface 26 for light rays emanating from the light source 29, except where the boundary layer 26 is locally interrupted at points 30, by intimate contact with highlights, surface projections or contours of an object 21, in this case by way of example a finger or thumb of a human hand. At such points 30 total internal reflection is no longer possible, because there is no refractive interaction between the media M1 and M2, but rather between the medium M1 and the object 21, which is in this case opaque or non-reflecting, at least along the required light path. Thus the image projected on the screen 37 will be one characterised by reproduction of the light source 29 less the local areas of contact 30 between the object 21 and the side of the internally reflecting surface 26 remote from the light source 29.

A preferred configuration, of the internally reflecting surface 26 comprises one surface of a glass prism, whose geometry and orientation with respect to the light source is such that light rays may enter without reflection through one surface 22 of the prism, to strike the internally reflective surface opposite thereto and thence emerge therefrom totally internally reflected, and without further reflection, through the third prism surface 23; the angles of incidence 28, 27, with the first and third surfaces being such as to obviate any reflection, and the media M1 and M2 in this case being respectively glass (solid) and air (gas). It is simply necessary to apply the object 21, whose image is to be viewed or projected in highlighted or silhouette form, to the second prism surface; in this case the longer surface 26 of the prism, to achieve local interruption of the internally reflected light rays 32, 33 and either a viewed

image or one projected upon the screen 37, the image reproducing or representing the totally internally reflected light source 29 locally interrupted by the regions of contrast 30. Thus, in the case of a finger or thumb held firmly against the external second surface 26 of the prism, the image formed by the projection means 36 will show the surface contours or highlights of the object 21, that is the finger or thumb 'print', as dark bands or lines against a light background. Photographic, or electronic optical scanning or other means may be employed to view and/or record the projected and highlighted image for permanent storage and retrieval and in this respect advanced electronic optical character recognition systems may usefully be employed to sort und distinguish between different finger 'prints' or 'print projections'.

The image recognition aspect of the invention may be exploited by using a recognition signal as a control signal to operate a device, for example a lock, which would only be activated by application of, say, a correct finger print to an optical recognition surface from which total internal reflection is produced as discussed above.

In certain specialised cases, where the object 21 or the surface contours thereof are not opaque, and thus have some refractive index in relation to that of the other medium M1, additional optical effects may be achieved and indeed exploited.

If the object 21 has a certain degree of resilience or flexibility, then it may be pressed into intimate contact with the reflecting surface 26, to bring substantially all the surface highlights into contact therewith and thereby to form a clear image thereof on the screen 37. However, in the case of a solid object, with surface projections of different height, it will be appreciated that contact cannot be achieved between all of such projections and the surface 26 if that surface is a rigid one. However, the surface 26 may in certain circumstances be resilient or flexible, depending upon the relative nature of the media M1 and M2, for example, a liquid media may be employed, in which case accomodation of the surface 26 to achieve a closer contact with the surface projections of the object 21 may be achieved, although preferably not to the extent of unduly complicating the light path for image formation, from the internally reflected, and in this case locally deformed, surface 26. Figure 2 shows a liquid immersion arrangement for an object with surface contours to be viewed.

Referring to Figure 2, an object 28 to be viewed is wholly or partly suspended (by means unshown) through a liquid medium M3 and thence into a liquid medium M4 of different refractive index. The viscosity and surface tension characteristics of the liquid M3 are such that it does not adhere unduuly to the object 28 and thus will readily be displaced by the liquid M4, which is in intimate contact with the surface contours 29 of the object 28 within a viewing area 30 for generally parallel incident light rays 32 at a normal or near normal angle of incidence with respect to the inter-liquid boundary 31 and from an unshown light source in or beyond the medium M4. The reflected image appears as surface contours in highlighted form against a background 33 reproducing the light source. The image indeed the local illumination of the surface contour 29 may be performed by simultaneous scanning with electro-optical devices to generate an electronic 'contour map' signal suitable for computer storage and processing.

Other applications of the invention may utilise the optical properties of thin solid or liquid films, for example, glass covered with a self-curing skin of synthetic plastics material to allow virtual 'straight on' or 90° scanning of convoluted surfaces. These optical properties will include particularly the albedo or reflective power of a material surface.

Claims

1. Image formation apparatus comprising a light source, an internally reflective surface defined at the boundary between two media of different refractive index, means for applying an object to locally interrupt said boundary surface, together with viewing or projection means for receiving and viewing or projecting an internally reflected image from said surface to form an image exhibiting contrast beween reflected and non-internally reflected light rays from such surface, in highlighted or silhouette form.

2. Apparatus as claimed in Claim 1, comprising a glass prism located in an air medium, to provide an internally reflective surface in the prism between the glass and air interface, for light rays from an image along a viewing axis, the reflective being along a projection or image viewing axis; means for applying an object with distinct surface contours to contact the glass air interface in order to interrupt locally the glass air interface and thereby locally to affect the internally reflective properties thereof, whereby to form a highlighted or contrasted image or relatively dark outlines of said object surface contours, against a relatively, light, silvered or reflected background, representing the light source.

3. Apparatus as claimed in Claim 2, comprising means for applying a finger-print as said object, whereby to project or view an image of said finger-print as a highlighted contoured outline.

4. Apparatus as claimed in any of the preceding claims, including an optical recognition device for responding to said highlighted or silhouette image for producing a control signal therefrom.

5. Apparatus as claimed in Claim 1, wherein one or both media comprise a liquid or gel in which all or part of the object is immersed.

6. Apparatus as claimed in Claim 1, wherein one of said media comprises a thin film applied to a surface or the other media.

7. A method of forming a highlighted or contoured image, comprising the steps of applying the three dimensional surface of an

object whose image is to be highlighted to an internally reflecting refractive surface layer between two media of respectively differing refractive index, to interrupt locally the internal reflection effect between the two media, whereby to produce said highlighted or contoured image in two dimensional form.

8. A method as claimed in Claim 7, including the steps of applying a permanent representation from an image of said contoured surface to be highlighted.

9. A method of projecting surface highlights or contours, comprising the steps of applying a surface to be projected and in particular the highlights or surface contours thereof, to the one side of an internally reflective surface, between one optical medium containing the surface and another optical medium of different refractive index, directing a light beam towards said surface at the opposite side thereof to said object, arranging a receiving, collating and projection means on the said side as said image or light source and directed to receive internally reflected light therefrom, and viewing direct or displaying a projected image therefrom.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1982. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.